Attachment E - Evaluation of Flow and Storm Surge Conditions Not Suitable for In-River Operations

High river flow or storm surge conditions could pose a safety risk to individuals performing construction or oversight activities related to the implementation of the remedy. Excessive loss of sediment could result if dredging continued during extreme flow or storm surge conditions. Specification of flow or storm surge conditions at which in-river construction would be suspended could have an impact on the number of planned dredging days lost over the course of the project, and potentially, an impact on the overall duration of construction. For the purpose of this analysis, river flow (or velocity) and/or tidal conditions that would signal a suspension of in-river operations are referred to as “cutoff” flows or velocities, or tidal conditions. Potential cutoff conditions were evaluated in several ways, with the simplest being river flow at Dundee Dam and tidal range, another being sediment mass resuspended as a function of river flow and tidal conditions, and a third being maximum velocities in different reaches of the river as a function of river flow.

Variations in River Flow and Tidal Ranges

Figure 1 shows the relationship between the number of dredging days that could be lost per year as a function of the cutoff flow using mean daily flow. This relationship is based on the cumulative frequency distribution of the period of record (February 1898 – 2015) of flows at the USGS gage at Little Falls, NJ (gage #01389500) and excludes the assumed “fish window” of March 1 through June 30. Figure 2 presents the same information in a slightly different manner, with potential dredging days lost as a function of a range of cutoff flows corresponding to fixed percentages from the cumulative distribution of daily flows (70 percent to 99.99 percent, with flows ranging from 965 to 20,576 cfs). A similar analysis was performed for tidal elevation conditions (Figure 3) using hourly water stage data. Because of gaps in the record at NOAA’s Bergen Point gage (Station #8519483 NY, near the Bayonne Bridge on the Kill Van Kull) data from the NOAA gage at the Battery in Manhattan (Station #8518750 NY) were used. Previous analyses (HDR, 2014) have shown a strong correspondence between data at the Battery and Bergen Point. Available hourly water surface elevation data were used to compute a maximum tidal range for each day, which is a better indicator of tidal flow than maximum elevation alone.

Bed Sediment Resuspension

The analysis of river flow (Figures 1 and 2) and tidal elevation condition (Figure 3) allows an assessment of the number a days of dredging that could be lost as a function of a cutoff flow or cutoff tidal range, but these analyses don’t provide a basis for selecting one cutoff versus another. Sediment resuspension as a function of river flow and tidal elevation range was examined in an attempt to provide a basis for selecting meaningful cutoff conditions. Model results from the No Action and Selected Remedy simulations were used to evaluate the relationship between sediment mass resuspended each day and river flow and tidal elevation range. Figure 4 presents the daily sediment mass resuspended per unit area versus river flow for one-mile reaches of the Lower 8.3-miles (with a 1.3 mile reach from RM 7 to

8.3) from the No Action model simulation. Different colors are used to distinguish the tidal range corresponding to each day's flow and resuspended mass. In reaches upstream of RM 2, the resuspended mass initially increases with increasing flow, and peaks before decreasing with increasing flow and then reaching an inflection point after which resuspended mass increases rapidly with increasing river flow. The inflection point in river flow that precedes the rapid increase in resuspension is lowest upstream (e.g., 2000 cfs) and increases to higher flows in subsequent reaches moving downstream (e.g., 4000 cfs between RM 2 and RM 4). It is only at the upper end of the range of flows that the resuspended mass exceeds the intermediate peak seen at flows ranging from 500 cfs upstream to 2000 cfs between RM 2 and RM 3. Downstream of RM 2, the relationship between resuspended sediment mass and river flow does not include an intermediate peak, but rather, generally increases with increasing river flow with almost two orders of variation at a given river flow and a clear response to increasing tidal range.

The same model output is presented on Figure 5 as resuspended sediment mass versus tidal range, with colors used to distinguish different ranges of river flow. Upstream of RM 2 the relationship between sediment resuspension and tidal range is somewhat variable, but downstream of RM 2 a clear relationship of increasing resuspension with increasing tidal range is seen, as is a gradient related to increasing river flow. Equivalent plots from the Selected Remedy simulation are shown on Figures 6 and 7, and although differences are noted between the two simulations, particularly in some of the more extreme resuspension values, the overall patterns are consistent. This suggests that, because of tidal flows, a wide range in sediment resuspension occurs over the range of typical flow conditions and that resuspension that exceeds the range computed under typical flow conditions is limited to more extreme flows. For this reason the most useful metric for evaluating conditions not suitable for in-river operations is river velocity.

Maximum Velocities

Because of the varying cross-sectional area within the lower 8.3 miles of the LPR, maximum velocities vary from reach to reach for a given river flow. Differences in velocities from reach to reach, therefore, allows for reach-specific evaluation of whether in-river operations could or should be conducted. Velocities seem a preferable metric compared to bottom shear stress (which was rejected after initial consideration) because measuring velocity is more straightforward and can be more readily considered with respect to safety by the construction and oversight contractors. Velocities vary vertically, with the maximum value typically at the surface, and therefore, surface layer velocities are used in the following analysis.

Maximum surface velocities from 8 one-mile reaches (RM 8.3 to RM 7 for the most upstream reach) are plotted versus river flow at Dundee Dam on Figure 8. Within each reach maximum velocities at any given river flow (within the more typical range) can vary over a range of one to two feet per second (fps) ; at the higher end of the flow range a more-limited number of occurrences of higher velocities are seen. In a limited number of cases, the maximum velocity was computed on the flooding tide, and these are shown as red dots. The point at which the band of velocities over a wide range of flows transitions to the sharper increase in velocity with river flow occurs at increasingly higher flows moving from upstream towards Newark Bay. The same velocities presented on Figure 8 are shown on Figure 9 as cumulative frequency distributions for each reach. The cumulative distributions of velocities were used to determine the number of days of dredging that could be lost as a function of a cutoff maximum velocity, as summarized in Table 1.

Table 1. Dredging Days Lost as a Function of Velocity Cutoff

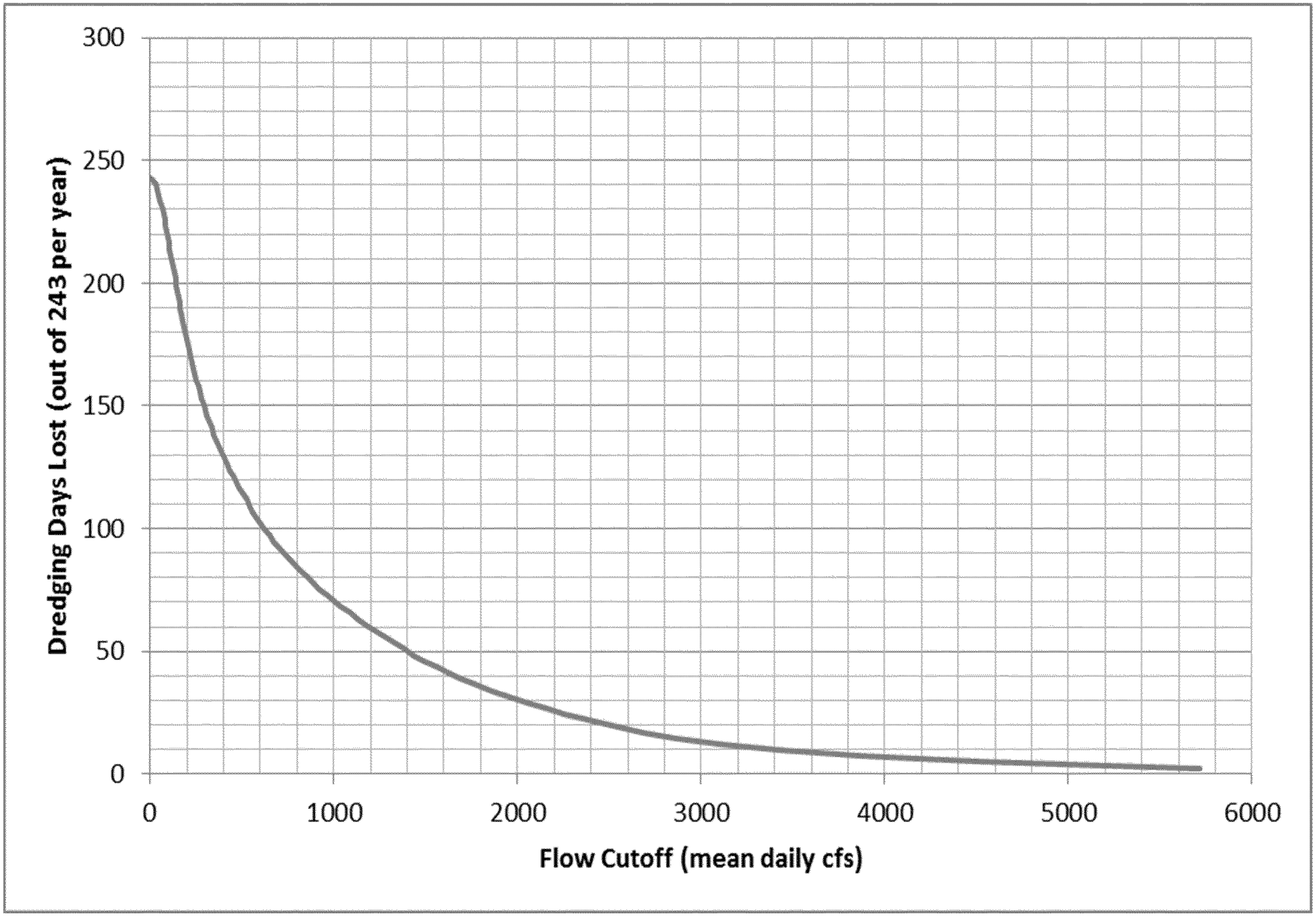
	Reach (River Mile)							
Absolute Maximum Surface Velocity (ft/s)	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8.3
2.0	227	241	242	242	240	229	212	228
2.5	144	214	223	226	221	167	90	138
3.0	41	122	132	142	156	73	15	33
3.5	3.5	38	29	39	64	17	3.5	8.7
4.0	0.2	4.2	2.2	3.4	11	2.5	1.8	4.4
4.5	0.1	0.4	0.8	1.0	1.3	0.6	0.8	2.6
5.0	0.0	0.3	0.4	0.5	0.4	0.4	0.4	1.9
5.5	0.0	0.1	0.3	0.3	0.3	0.3	0.3	1.0
6.0	N/A	0.0	0.3	0.3	0.3	0.2	0.3	0.5
6.5	N/A	0.0	0.2	0.2	0.2	0.0	0.0	0.3
7.0	N/A	N/A	0.1	0.0	0.0	N/A	N/A	0.2
7.5	N/A	N/A	0.0	0.0	N/A	N/A	N/A	0.0

Conclusions

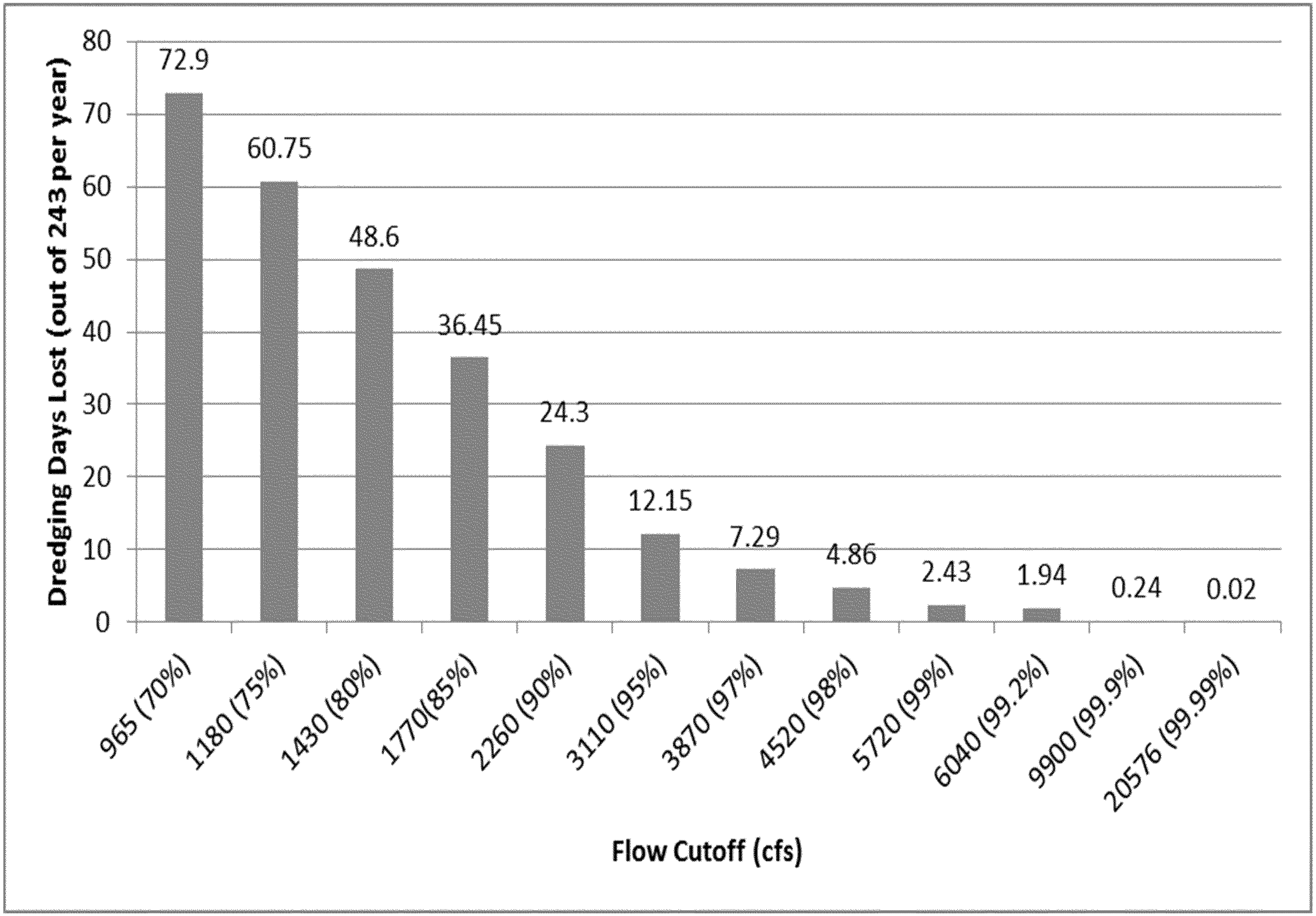
Consideration of long term variations in river flows and tidal ranges, coupled with analysis of sediment resuspension computed over a 17-year model simulation indicate that river flow is not a spatially uniform metric that should be used to determine suitable conditions for in-river operations. Surface velocities may provide a metric that addresses both maritime operation and safety considerations. Based on the representativeness of the simulated hydrograph as a surrogate for the long-term hydrograph, this analysis provides an estimate for the number of dredging days that could be lost for specific cutoff velocities. For instance, a cutoff velocity of 4 fps would result in the loss of 0.2 to 11 days of dredging per year, depending on the reach, while a cutoff of 3.5 fps would result in the loss of 3.5 to 64 days of dredging per year. A specific cutoff velocity is not recommended based on this analysis, but this information is provided for consideration by those with appropriate expertise for making such a recommendation.

References

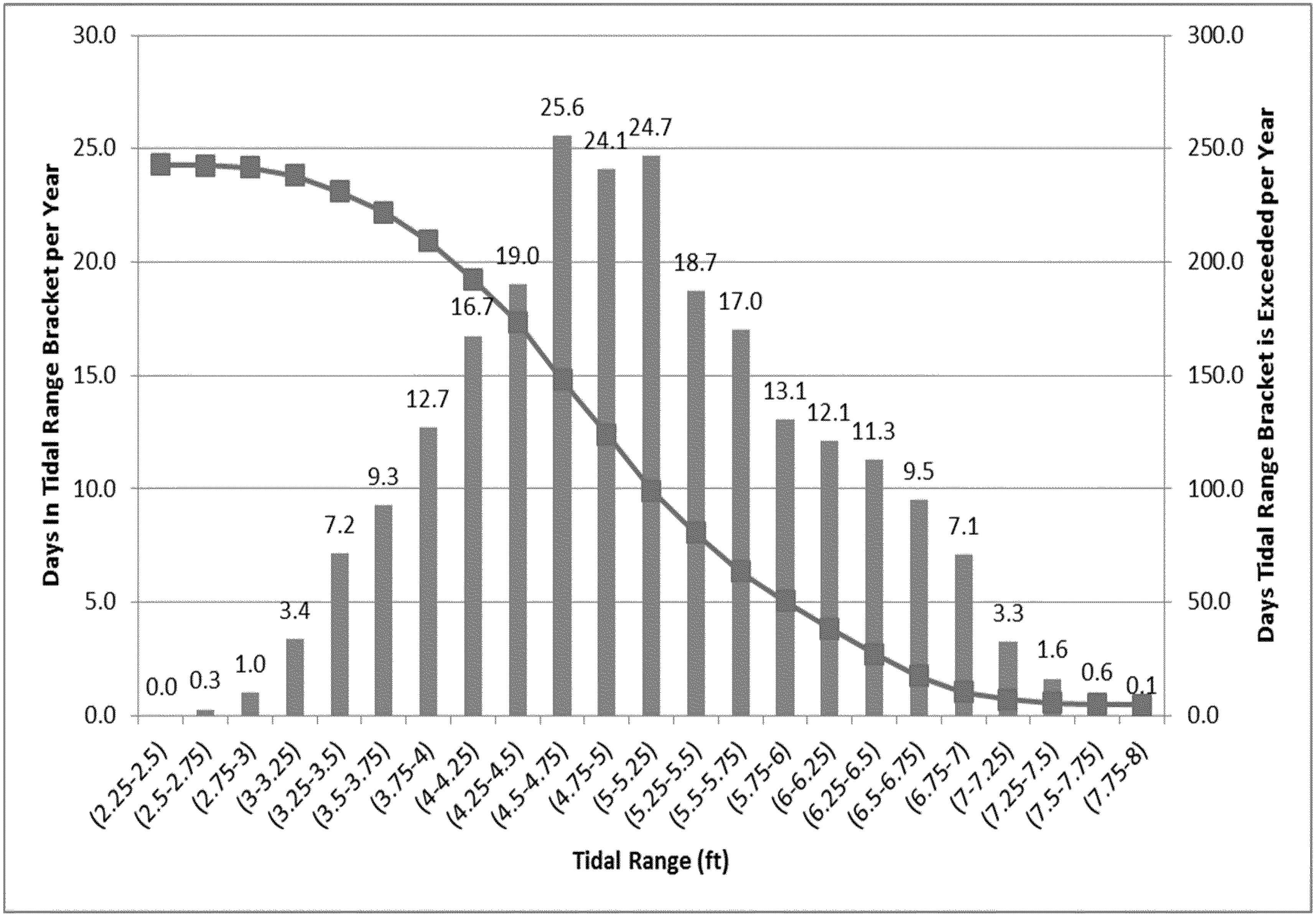
HDR, Inc., 2014. "Hydrodynamic and Sediment Transport Evaluation: Capping/Armoring Analyses for the Focused Feasibility Study Area. Appendix BI of the Focused Feasibility Study Report." Prepared for EPA under subcontract to The Louis Berger Group and US Army Corps of Engineers. 2014.



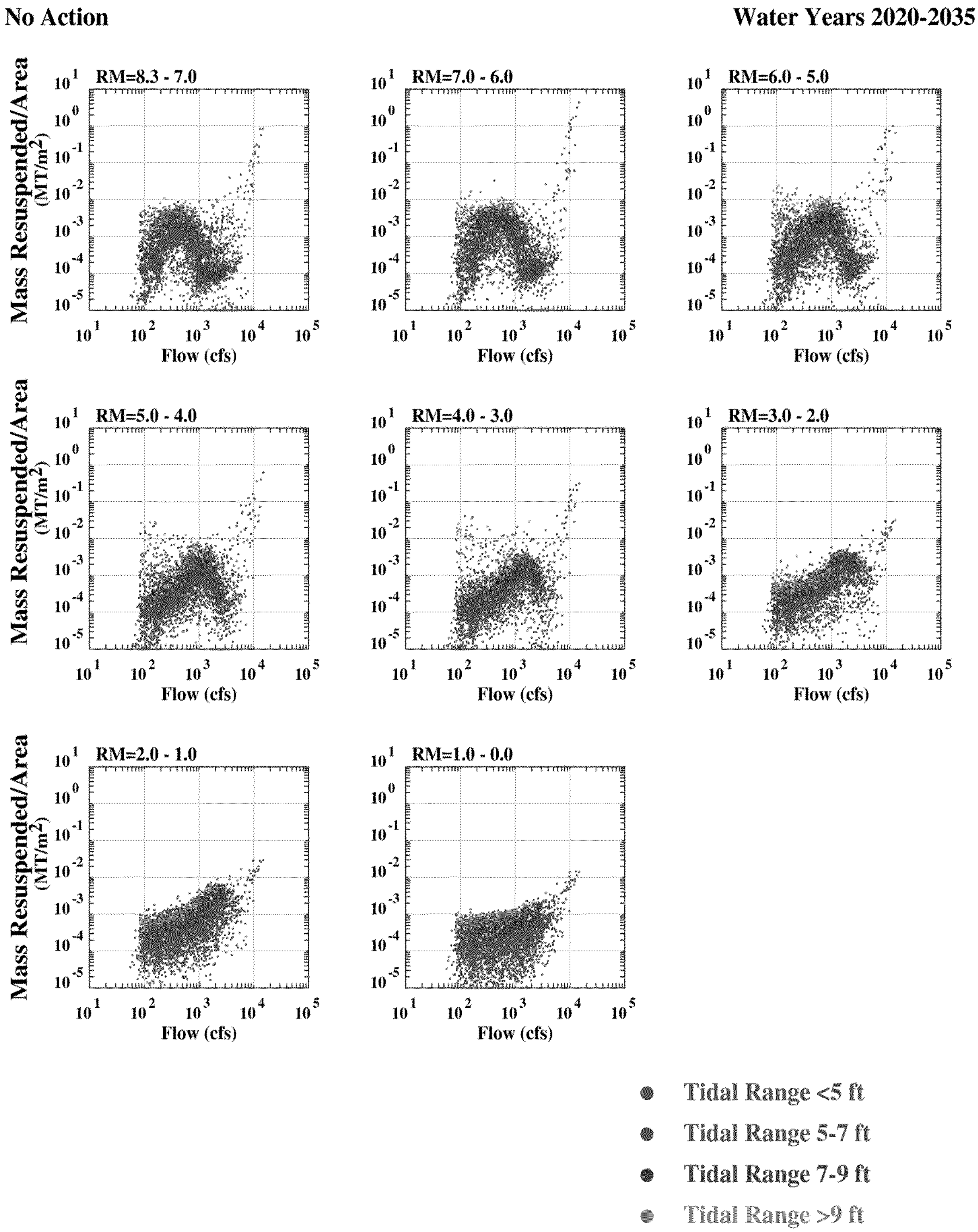
Dredging days lost as a function of cutoff flow based on USGS gage at Little Falls (1898-2015). Excludes March 1 - June 30 fish window *Lower 8.3 Miles of the Lower Passaic River*	Figure 1 2016



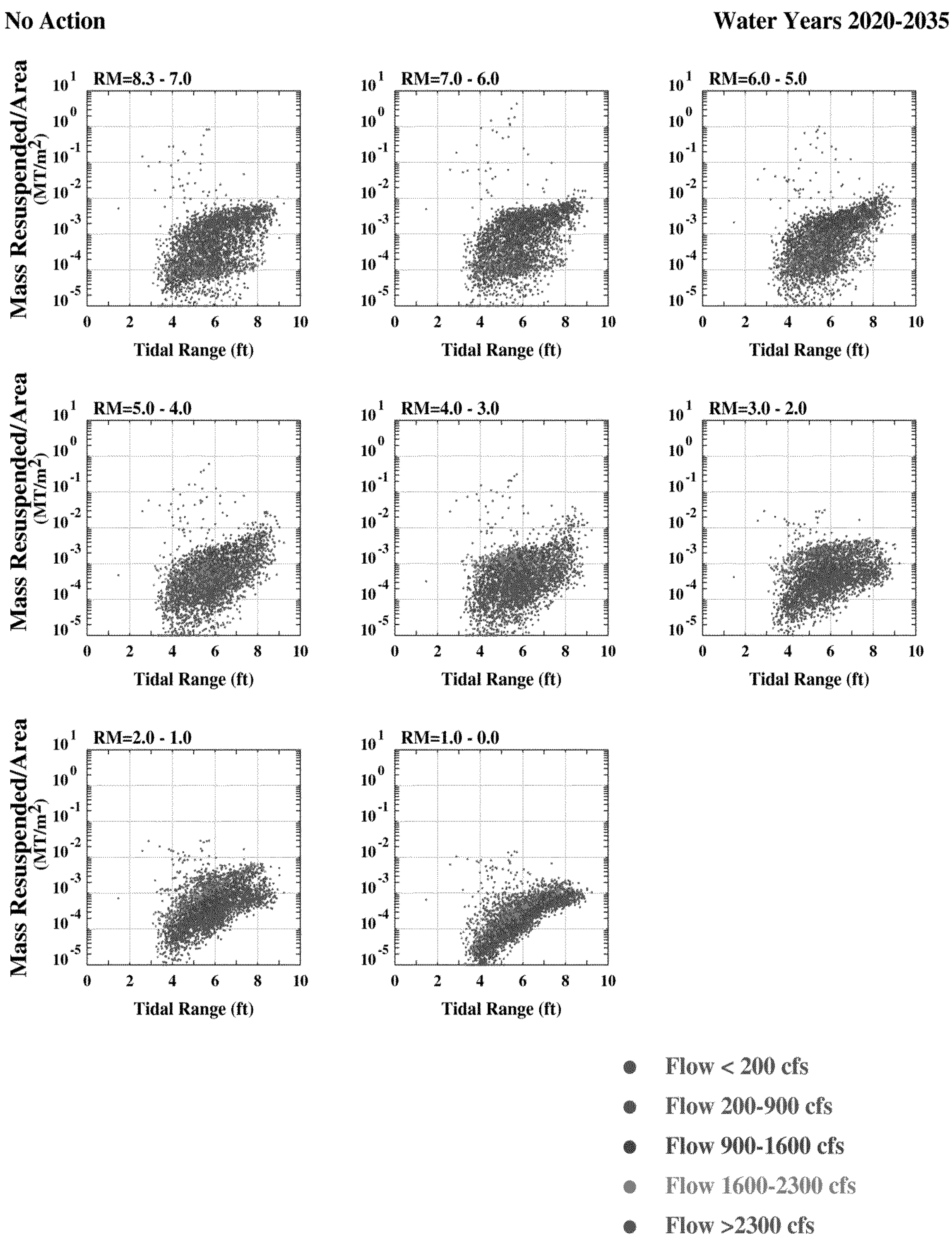
Dredging days lost for cutoff flows at selected pecentile from cumulative frequency distribution forUSGS gage at Little Falls (1898-2015). Excludes March 1- June 30 fish window *Lower 8.3 Miles of the Lower Passaic River*	Figure 2 2016



Dredging days lost as a function of cutoff tidal range. Excludes March 1 - June 30 fish window	Figure 3
Lower 8.3 Miles of the Lower Passaic River	2016



Daily sediment mass per area resuspended as a function of river flow for No Action simulation *Lower 8.3 Miles of the Lower Passaic River*	Figure 4 2016

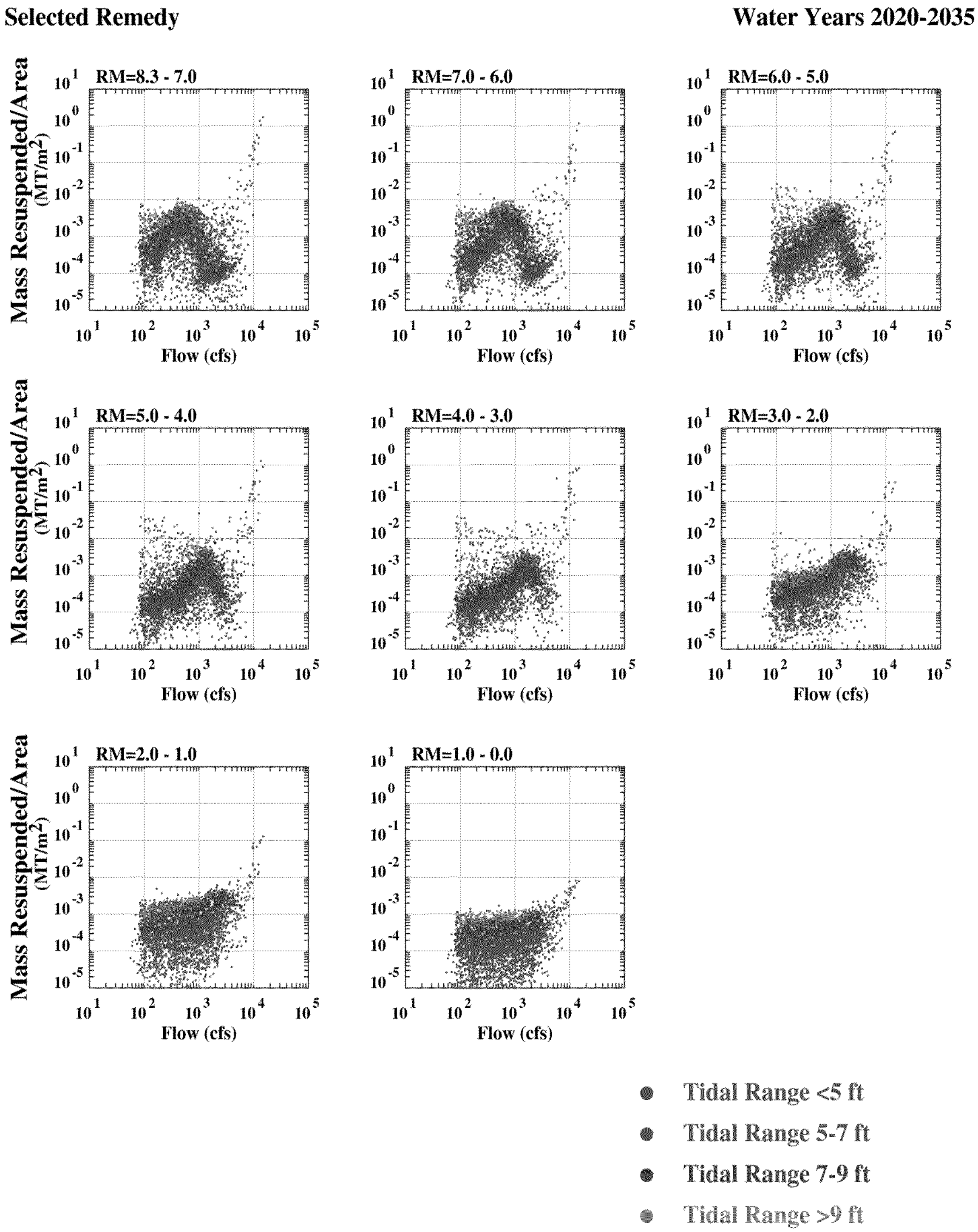


Daily sediment mass per area resuspended as a function of tidal range for No Action simulation

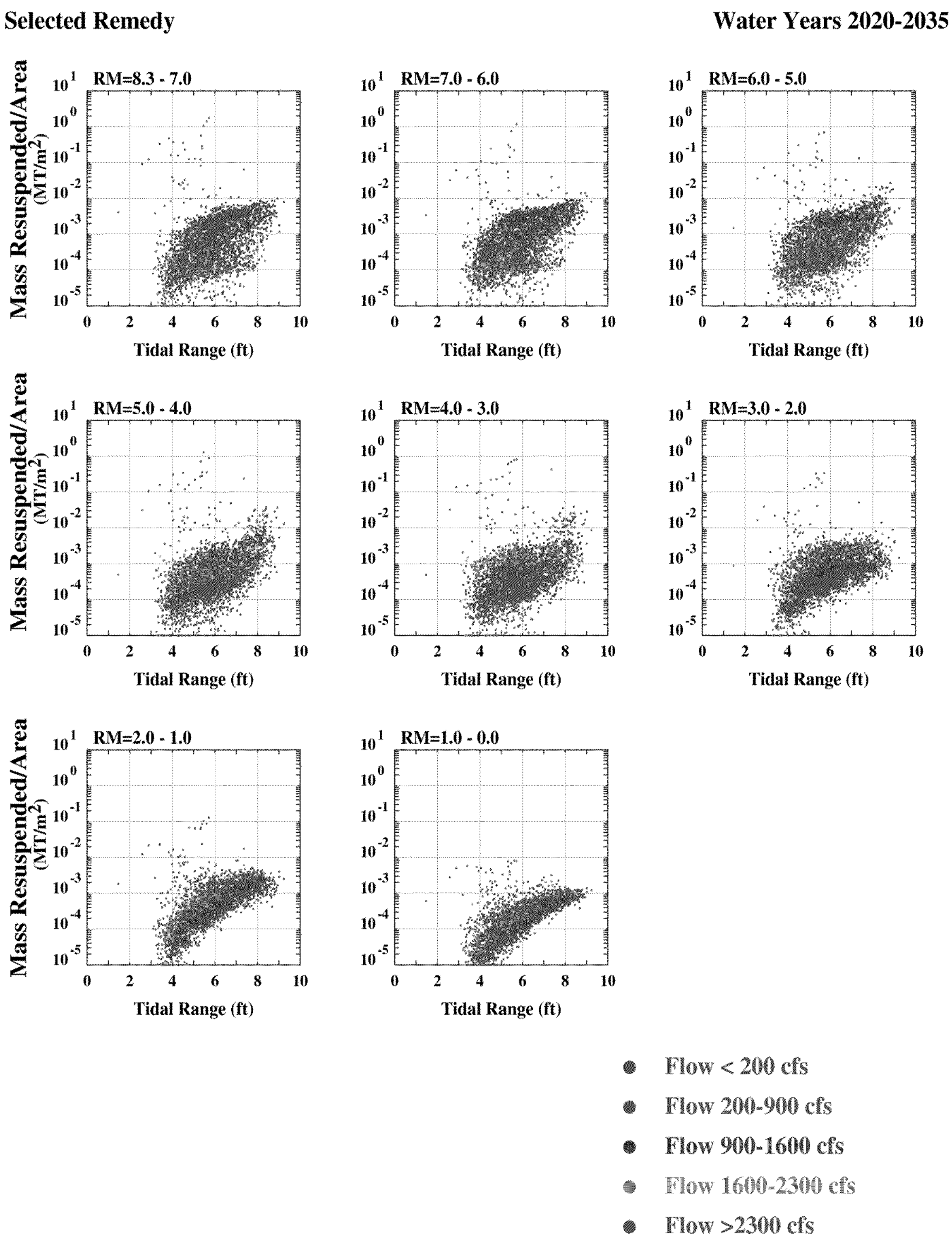
Lower 8.3 Miles of the Lower Passaic River

Figure 5

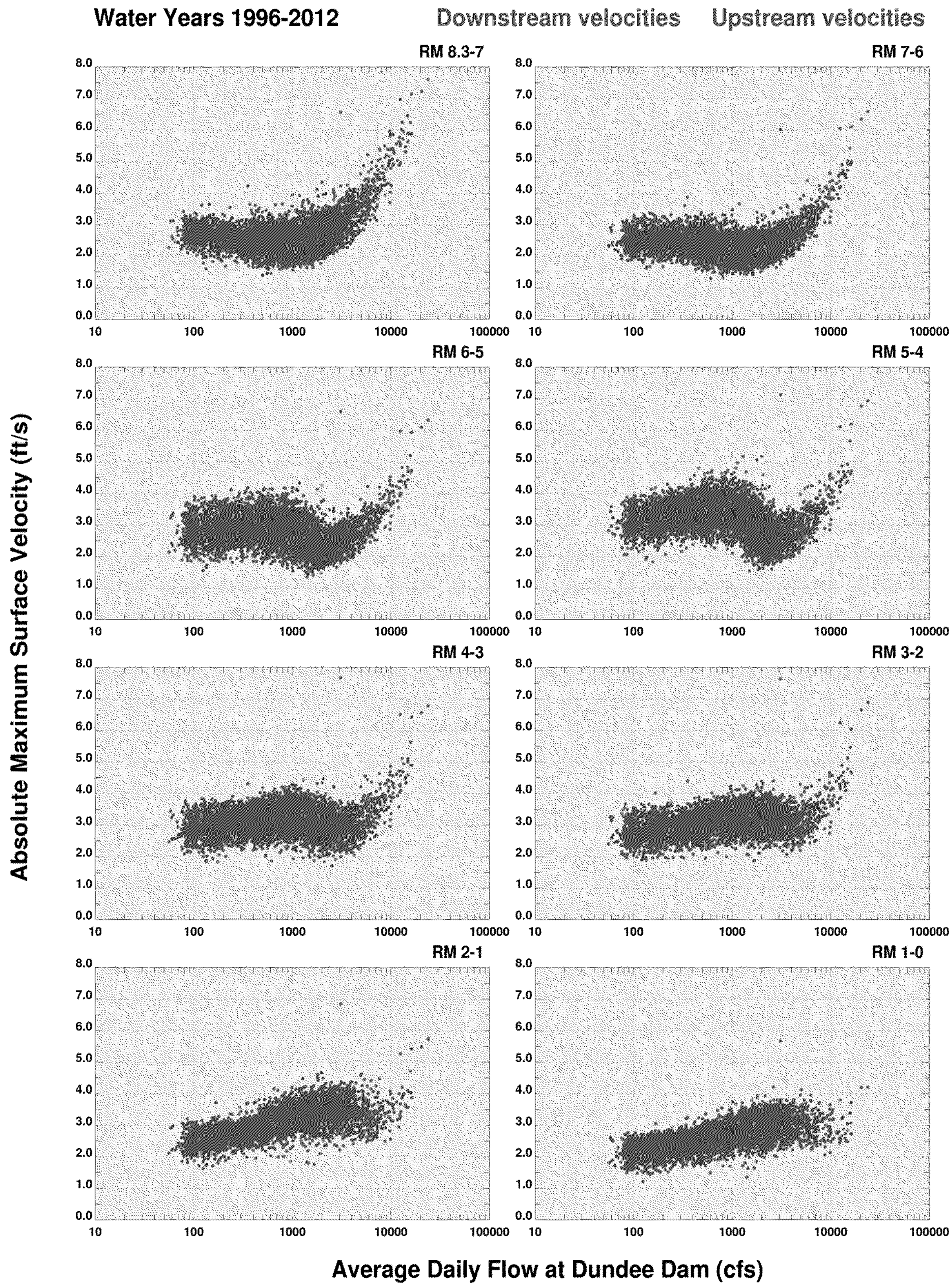
2016



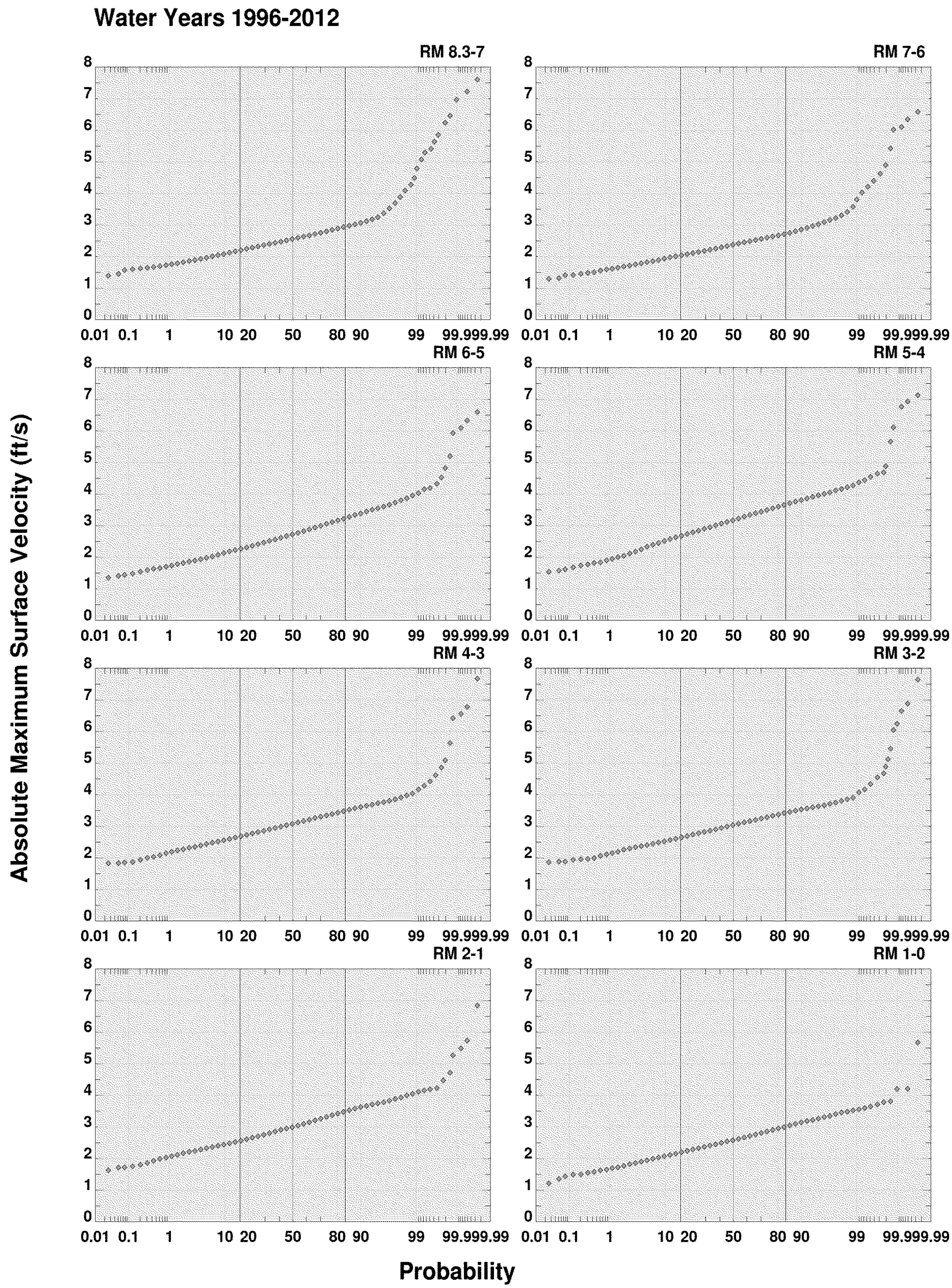
Daily sediment mass per area resuspended as a function of river flow for Selected Remedy simulation *Lower 8.3 Miles of the Lower Passaic River*	Figure 6 2016



Daily sediment mass per area resuspended as a function of tidal range for Selected Remedy simulation *Lower 8.3 Miles of the Lower Passaic River*	Figure 7 2016



Maximum surface velocity as a function of river flow	Figure 8
Lower 8.3 Miles of the Lower Passaic River	2016



Probability of maximum surface velocity by reach	Figure 9
Lower 8.3 Miles of the Lower Passaic River	2016